Assessment on the LCOE for micro-grids in West Africa

Pol Arranz-Piera, Frederic Horta

UNIVERSITAT POLITÈCNICA DE CATALUNYA
BARCELONA**TECH**

**University Research Institute
for Sustainability Science and Technology**

UNIVERSITAT POLITÈCNICA DE CATALUNYA
BARCELONA**TECH**

Research Group on Cooperation and
Human Development - GRECDH

UNIVERSITAT POLITÈCNICA DE CATALUNYA
BARCELONATECH
UPC
University Research Institute
for Sustainability Science and Technology

Contents

- Our vision: Strategic planning principles for decentralised rural electrification (DRE)

- Use of LCOEs in the planning decision flow

- Microgrid example: Monte Trigo community (Cape Verde)

- The "ENERGY for ALL 2030" project

Strategic planning principles in DRE

• Lack of integrated evaluation in rural electrification planning hinders RET success (Silva and Nakata, 2009).

• Importance of double perspective of electricity as **service** to cover **basic AND productive** uses (Brew-Hammond, 2010), (ARE, 2011)

• Key components for an integrated approach:

Programme / Project	Goal (as a service)
Social Development / Social Integration	*Equity*
Technical / Technological	*Reliability*
Institutional / Organisational	*Empowerment*
Financial / Economic	*Viability*

3

Use of LCOEs – Levelized cost of energy

$$EGC = \Sigma \left[(I_t + M_t + F_t)(1+r)^{-t} \right] / \Sigma \left[E_t (1+r)^{-t} \right]$$

With:

EGC = Average lifetime levelised electricity generation cost

I_t = Investment expenditures in the year t

M_t = Operations and maintenance expenditures in the year t

F_t = Fuel expenditures in the year t

E_t = Electricity generation in the year t

r = Discount rate

(source: NEA-IEA, 2005)

The LCOE depends heavily on **assumptions** about:

o Capital costs (initial investments generation + distribution)

o Fixed O&M (salaries & wages, administration, regular maintenance, insurance, ...

o Variable O&M (periodic inspection, replacement, and repair of system components)

o Fuel

o Discount rate, inflation, ...

→ *Lifetime* and *Sizing* required (supply side? demand analysis?)

→ *Scope* width (cross-country, specific project...) limits accuracy

→ *Risks* assessment, experience being gained in on-going projects

Renewable Energy based Microgrids

Some published references on LCOE generation :

• Minigrid PV systems Africa: 0.2 to 0.55 EUR/kWh (Szabó, 2011)

• (ESMAP 2007) Mini-grids - projection 2015 (life span 20 years):

- o Solar PV (25kW): 0.3 to 0.52 USD/kWh
- o Wind (100kW):   0.15 to 0.22 USD/kWh
- o PV-Wind hybrid (100kW):   0.22 to 0.30 USD/kWh
- o Biomass gasifier (100kW): 0.07 to 0.10 USD/kWh
- o Micro-hydro (100kW):   0.09 to 0.12 USD/kWh

• Most authors develop their own spreadsheet models for cash flow projection; for quicker ("engineering") appraisal, HOMER (NREL) is a popular tool

Institut Universitari de Recerca en Ciència i Tecnologies de la Sostenibilitat IS.UPC
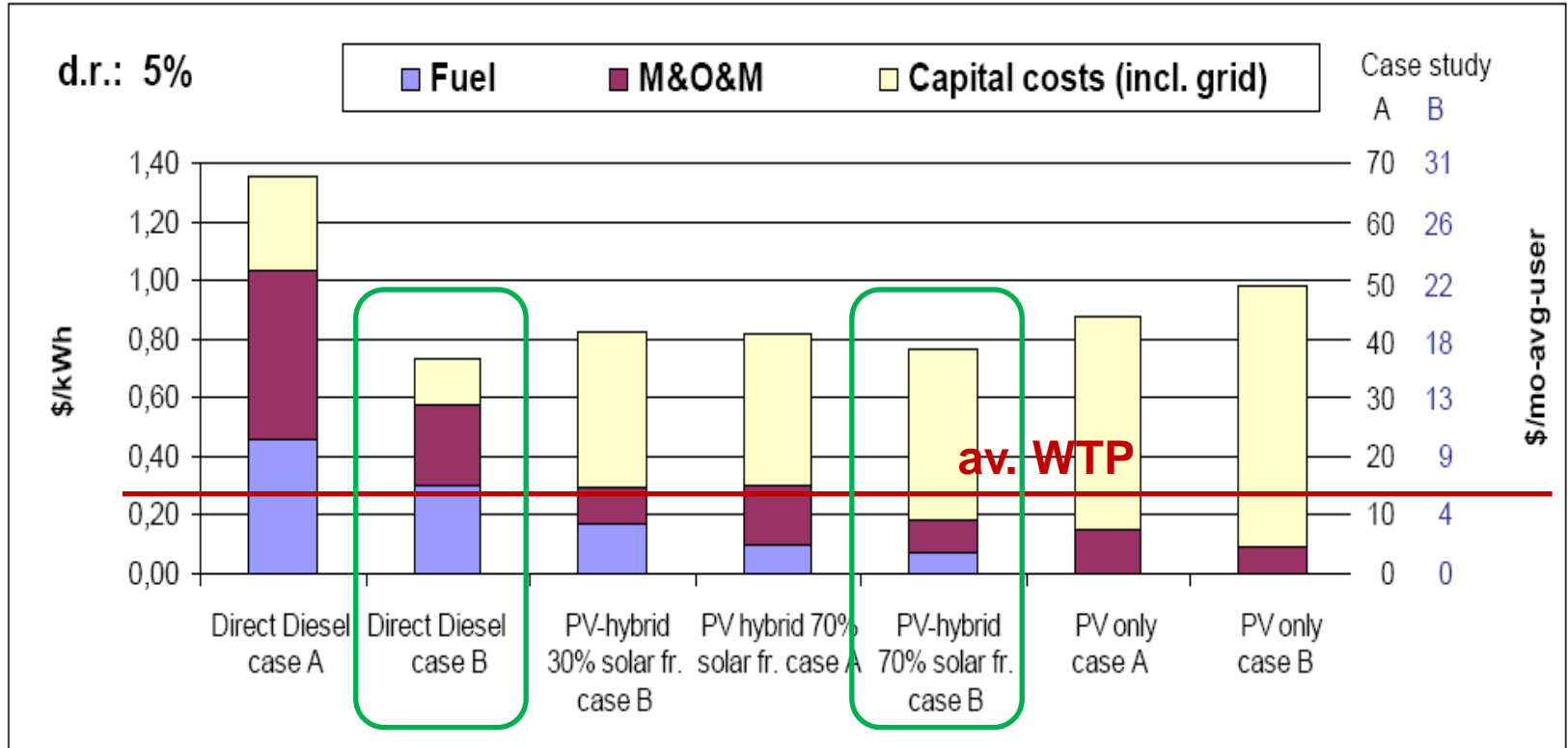
Financial – Economic component → Viability!

Figure 3.- Breakdown of levelized energy costs in Floreana (case A) and Padre Cocha (case B) at 10% and 5% discount rates. Average kWh cost are acceptable to compare different solutions for one application, but for different systems for different locations and small demands, transaction costs, local management, etc, represent a high fraction of the service costs, and the cost per user must also be assessed.

Source: Arranz-Piera, P. Vallvé, X., González, S. (2006)

6

UNIVERSITAT POLITÈCNICA DE CATALUNYA
BARCELONATECH
University Research Institute
for Sustainability Science and Technology

PV microgrid in Monte Trigo (Cape Verde)

Photo credit: TTA

ACP-EU Energy Facility

project partners:
- Aguas de Ponta Preta (APP), Cape Verde
Camara Municipal Porto Novo, Cape Verde
- Universidad de Lisboa, Portugal
-Transenergie, France
- Trama Tecnoambiental (TTA), Spain

- 27kWp PV microgrid for 60 households, school, medical centre

- 600 inhabitants

- Hostel for visitors, small shops, telecommunications, TV, ice making machine

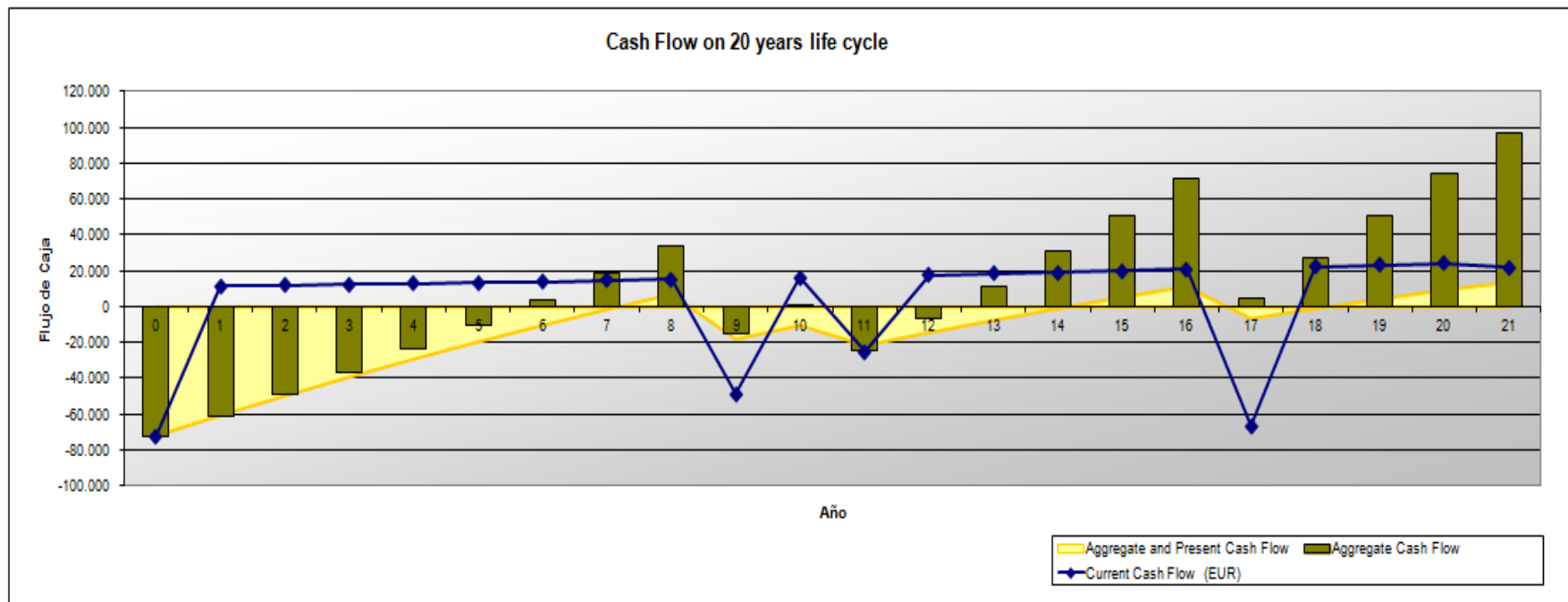- 24 hour electricity service since February 2012

7

UNIVERSITAT POLITÈCNICA DE CATALUNYA
BARCELONATECH
University Research Institute
for Sustainability Science and Technology

PV microgrid in Monte Trigo (Cape Verde)

Discount rate: 8,5%
Lifetime: 20years

LCOE (generation) :   0.24 EUR/kWh
LCOE (net demand): 0.36 EUR/kWh

Cash Flow on 20 years life cycle

Legend: Aggregate and Present Cash Flow | Aggregate Cash Flow | Current Cash Flow (EUR)

NPV   13.871 EUR   Sustainable Project

PV microgrid in Monte Trigo (Cape Verde)

Without demand management system → reduced components life

Discount rate: 8,5%   LCOE (generation):   0.29 EUR/kWh   (↑20%)
Lifetime: 20years   LCOE (net demand): 0.43 EUR/kWh
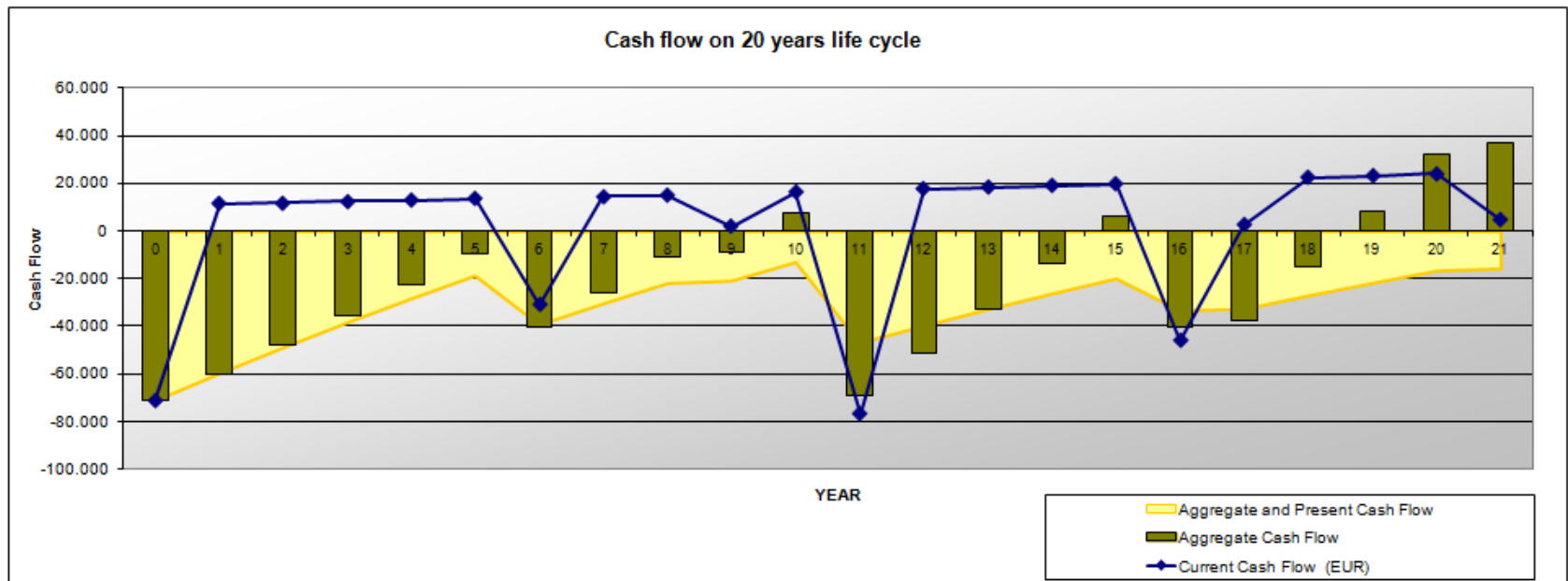
NPV   -15.606 EUR   Project NOT Sustainable

Acknowledgment

Project: **Energy Access for the Poor in sub-Saharan Africa to meet the Millennium Development Goals**
"ENERGY FOR ALL 2030"

Partners: Practical Action (UK), EDUCON (Czech Republic) Stockholm Environment Institute (SWE), UPC (ESP)

http://grecdh.upc.edu/projects/other/e4a-2030

Institut Universitari de Recerca en Ciència i Tecnologies de la Sostenibilitat IS.UPC

UNIVERSITAT POLITÈCNICA DE CATALUNYA
BARCELONATECH
University Research Institute
for Sustainability Science and Technology

- Diego Silva Herran, Toshihiko Nakata (2009). Multi-objective assessment of rural electrification in remote areas with poverty considerations. Energy Policy 37 (2009), pp 3096–3108.

- Brew-Hammond, A (2010) Energy access in Africa: Challenges ahead. Energy Policy 39 (2010), pp 2291-2301

- USAID/ARE. (2011). Hybrid mini-grids for rural electrification: lessons learned. Washington D.C. and Brussels: USAID and the Alliance for Rural Electrification.

- NEA-IEA (2005). Nuclear Energy Agency - International Energy Agency. Projected Costs of Generating Electricity. 2005 Update

- S Szabó et al. (2011). Energy solutions in rural Africa: mapping electrification costs of distributed solar and diesel generation versus grid extension. Environ. Res. Lett. 6 (2011) 034002

- ESMAP (2007). Technical and Economic Assessment of Off-grid, Mini-grid and Grid Electrification Technologies. ESMAP Technical Paper 121/07. Washington D.C. World Bank.

- Arranz-Piera P., Vallvé X., González S. (2006), Cost effectiveness of PV hybrid village power systems vs. conventional solutions. 3rd European Conference PV-hybrid and mini-grid, 11-12 May 2006 Aix en Provence, France.

11

Institut Universitari de Recerca en Ciència i Tecnologies de la Sostenibilitat IS.UPC

Thank you very much for your attention

Pol Arranz Piera
pol.arranz.piera@upc.edu

http://grecdh.upc.edu/projects/other/e4a-2030